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Original Research

The effects of iron nanoparticles on physiological and biochemical characteristics of forage maize (*Zea mays* L.) at different growth stages

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ABSTRACT:

An investigation was initiated to study the effects of different concentrations of iron nanoparticles on physiological and biochemical characteristics of forage maize (*Zea mays* L.) at different growth stages. The main factor (factor A) was different growth stages (rapid vegetative growth, early flowering and after flowering) and the sub factor (factor B) was spraying with iron nanoparticles at different levels (0, 0.01%, 0.03% and 0.05%). Results indicated increasing effects of boat treatments and also interaction between them on different physiological and biochemical studied characteristics of maize.

Keywords:

Forage maize, growth stages, iron nanoparticles, spraying.

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INTRODUCTION

Maize or corn (*Zea mays*) belongs to the grasses (Poaceae) family. Maize is developed internationally and being the most imperative and vital grain crops around the world. This plant has a generally short growing period and produces a high return. It isn't just a vital human supplement, likewise an essential component of animal feed and raw material for making of numerous industrial products, for example, corn starch, maltodextrins, corn oil, corn syrup and products of fermentation and refining industries. It is additionally being utilized as biofuel. (Tripathi *et al.,* 2011; Morteza *et al.,* 2013).

Micronutrient deficiency is one of the main problems limiting agricultural productivity, especially in alkaline calcareous soils (Mosanna and Behrozyar, 2015). Million hectares of cultivable land in the world lack one or several micro nutrients. Iron is a vital micro nutritional catalyst impetus to chlorophyll biosynthesis and goes about as an oxygen carrier and helps in respiratory enzyme systems in plants. It is reported that maize is rather sensitive to iron deficiency (Monreal *et al.,* 2015; Gholami *et al.,* 2013).

More than three billion individuals over the world experience the ill effects of micronutrient deficiencies so it is proposed that a lot of research in the 21st century ought to be dedicated to grow new advancements, for example, nanotechnology for improved take-up and accumulation of micronutrients in the palatable plant parts. (Graham *et al.,* 2001; Prasad *et al.,* 2012). Nanoparticles with 1-100 nm in diameter have an large particular surface zone and can give highest amount of reactivity which encourages effective absorption. Nanoparticles, for example, nano, TiO_2 nano zinc, nano-iron, nano-aluminum could be utilized to build the resource of components to plant shoots and foliage. Likewise utilization of nanoparticles can enhance seed germination, seedling growth, encourage improved capacity of water and manure assimilation by roots and enhances antioxidant enzyme activity, for example, superoxide dismutase, catalase, and subsequently enhanced plant protection against different stresses. (Morteza *et al.,* 2013).

Almeelbi and Bezbaruah (2014) studied the effect of iron nanoparticles on spinach in hydroponic solution and they reported significant enhancement in plant growth and biomass by nanoparticles. Interestingly iron content in spinach roots, stem and leaves increased 11-21 times. Also in another research Fe_2O_3 nanoparticles were given to soybean by foliar application and soil route (Alidoust and Isoda, 2013). Root elongation and photosynthetic potential fundamentally upgraded by foliar utilization of NPs yet this improvement was far less when NPs were given to plant through soil route which might be because of the precipitation of Fe ions. (Singh *et al.,* 2015). In a study about the effects of iron oxide nanoparticles on some quantity, quality

Table 1. Analysis of variance of biochemical traits

		Mean square									
S. No	S.O.V	Chll a	Chll b	Cart	Proline	CAT	POX	SOD	TSS	SLPs	MDA
1	A	0.02 ns	0.009 ns	0.038 ns	53.32 ns	35.61 ns	1.97 ns	0.92 ns	90.92 *	0.63 ns	0.000007 ns
2	E(A)	0.07	0.007	0.022	67.52	112.89	16.86	1.23	98.41	2.07	0.000007
3	B	0.47 *	0.10 **	0.43 **	147.46 ns	52.94 ns	2.92 *	1.74 ns	72.45 *	1.5 **	0.00001 ns
4	A×B	0.13 ns	0.64 ns	0.006 ns	46.93 ns	26.37 ns	0.47 ns	0.62 ns	20.13 ns	1.01 ns	0.00001**
5	E(B)	0.15	0.0095	0.018	51.56	23.67	21.43	0.67	23.99	1.61	0.0000033
6	CV%	14.7	26.33	22.17	10.07	14.7	21.4	21.06	15.19	12.56	7.36

ns, * and **: Not significant, significant at the 5% and 1% levels, respectively

Table 2. Analysis of variance of some physiological traits

		Mean square									
S. No	**S.O.V**	**Leaves dry weight**	**Stem dry weight**	**Ear dry weight**	**Seed dry weight**	**Plant height**	**Ear height**	**No. of leaf**	**Leaf length**	**Leaf width**	**Length of ear bald tip**
1	A	0.007 ^{ns}	0.007 ^{ns}	0.05 ^{ns}	0.0063 ^{ns}	0.86 ^{ns}	15.14 ^{ns}	2.37 **	6.03 ^{ns}	0.21 ^{ns}	1.25 ^{ns}
2	E(A)	0.04	0.047	0.07	0.035	0.18	142.0	1.47	26.58	0.48	11.10
3	B	0.04 ^{ns}	0.013 ^{ns}	0.14 *	0.12 **	0.59 ^{ns}	20.35 ^{ns}	0.31 ^{ns}	2.25 ^{ns}	0.01 ^{ns}	4.79 ^{ns}
4	A×B	0.009 ^{ns}	0.0081 ^{ns}	0.023 ^{ns}	0.0046 ^{ns}	0.47 ^{ns}	4.52 ^{ns}	0.17 ^{ns}	18.33 ^{ns}	0.53 *	4.63 ^{ns}
5	E(B)	0.015	0.02	0.037	0.01	216.61	62.14	0.38	8.62 ^{ns}	0.18	0.31
6	CV%	14.47	12.39	18.55	16.56	4.01	15.27	3.95	4.0	4.19	8.19

ns , * and* *: Not significant, significant at the 5% and 1% levels, respectively

and physiological characteristics in four wheat (*Triticum aestivum* L.) cultivars, they identified significant changes relate to numerous characteristics including, leaf area, duration, net digestion rate, growth rate, relative growth rate, grain and biological yield, harvest index, SDS silt, grain protein, and iron contents (Isvand *et al.,* 2014).

To utilize chemical manures productively, it is fundamental that fertilizer is applied by foliar-applications. The foliar application is the most ideal approach to support plants that grow up in the soil with low quality because of adverse pH (Ishii *et al*., 2002, Mosanna and Behrozyar, 2015). The objective of this study was to explore the impacts of Iron nanoparticle spraying on morpho-physiological qualities of maize at various development stages.

MATERIALS AND METHODS

This experiment was conducted in the year 2015 at the experimental field of the Sugar Beet Seed Research Institute (SBSI), Karaj, Alborz province, Iran (50^0 58' E, 35^0 50' N, elev. 1313.). The experimental design was a split-split plots in the form of complete randomized block design with four replications. The main factor (factor A) was different growth stages in three levels including rapid vegetative growth, early flowering and after flowering. Also the sub factor (factor B) was spraying with iron nanoparticles at four levels including control (0), 0.01%, 0.03% and 0.05%. Maize seeds of cultivar 704 (adapted to the region) were planted in the middle of May with 70 cm row spacing and 12 cm plant spacing. Biochemical characteristics which were measured during this study were chlorophyll a, chlorophyll b, carotenoid, Catalase (CAT), Peroxidase (POX), Superoxide Dismutase (SOD),

Table 3. Analysis of variance of some physiological traits

	Mean square									
S.O.V	**Stem Diameterd**	**No. of inter-node**	**Distance of internode**	**No. of ears**	**Ear length**	**Ear diameter**	**Ear wood length**	**Ear tail diameter**	**Ear tail length**	**Ear wood diameter**
A	0.34 ^{ns}	2.01 *	0.43 ns	0.0058 ^{ns}	38.71 **	66.38 ^{ns}	7.4 ^{ns}	3.32 ^{ns}	6.58 *	36.27 *
E(A)	5.55	1.66	2.57	0.0036	28.79	69.49	20.13	10.55	7.77	38.02
B	0.78 ^{ns}	0.49 ^{ns}	1.8 ^{ns}	0.002 ^{ns}	9.24 ^{ns}	22.76 ^{ns}	1.51 ^{ns}	0.9 ^{ns}	0.13 ^{ns}	6.14 ^{ns}
A×B	2.43 ^{ns}	0.46 ^{ns}	1.62 ^{ns}	0.004 ^{ns}	8.14 ^{ns}	24.53 *	22.55 ^{ns}	1.36 ^{ns}	1.4 ^{ns}	6.14 ^{ns}
E(B)	1.98	0.44	1.26	0.0053	6.7	8.32	3.65	2.48	1.54	8.25
CV%	6.26	4.22	7.2	7.2	10.89	8.15	11.12	18.0	17.79	15.7

ns, * and **: Not significant, significant at the 5% and 1% levels, respectively

Table 4. Analysis of variance of some physiological traits

		Mean square				
S. No	S.O.V	Tassel length	No. of rows on each ear	No. of seed per row	Total seeds on ear	Yield (in hectare)
1	A	1.25 [ns]	0.86 [ns]	15.14 [ns]	7867.64 [ns]	39484375 [ns]
2	E(A)	11.10	0.18	142.0	33150.53	149164931
3	B	4.79 [ns]	0.59 [ns]	20.35 [ns]	3373.9 [ns]	54407986 [ns]
4	A×B	4.63 [ns]	0.47 [ns]	4.52 [ns]	1819.45 [ns]	872153 [ns]
5	E(B)	8.04	0.34	30.44	8354.49	47750579
6	CV%	8.19	4.01	15.27	17.2	13.54

ns , * and**: Not significant, significant at the 5% and 1% levels, respectively

proline, Malondialdehyde (MDA), Soluble Leaf Proteins (SLPs) and Total Soluble Solids of leaf (TSS). Also many physiological traits were studied include plant height, ear height, number of leaves, leaf length, leaf width, stem diameter, number of internode, ear length, ear diameter, length of ear bald tip, ear dry weight, number of seed per row, total seeds on ear, yield (in hectare) and another measured physiological characteristics which are represented in (Tables 1, 2, 3 and 4).

RESULTS AND DISCUSSION

According to the analysis of variances (Tables 1 and 2) the main factor (different growth stages) had significant effect on some biochemical and physiological traits including total soluble solids of leaf (P≤0.05), number of leaves (P≤0.01), number of internode (P≤0.05), ear length (P≤0.01), ear tail length (P≤0.05) and ear wood diameter (P≤0.05). Results of the means of comparison (Table 7) showed that early flowering stage (A2) caused highest rate of total soluble solids of leaf (32.11), number of leaves (15.53) and ear length (24.94). Also after flowering (A3) resulted highest amount of number of internode (16.1), ear tail diameter (7.41 mm) and ear wood diameter (19.61 mm). Results of variance of analysis identified the sub factor (different concentrations of spraying with iron nanoparticles) and had significant effect on physiological traits including ear dry weight (P≤0.05) and seed dry weight (P≤0.01) but this treatment represented more significant effects on biochemical characteristics including chlorophyll a (P≤0.05), chlorophyll b (P≤0.01), carotenoid (P≤0.01), peroxidase (P≤0.05), total soluble solids of leaf (P≤0.05) and soluble leaf proteins (P≤0.01). Mean of comparison analysis revealed that highest level of iron nanoparticles (0.05%) resulted in the highest amount of seed dry weight (710 gr), chlorophylla (2.85), chlorophyll b (0.51), carotenoid (0.88) and peroxidase (4.82) while applying 0/03% of iron nanoparticles (B3) it showed maximum effect on ear dry weight with 1120 gr and using of 0.01% iron nanoparticles (B2) resulted highest amount of total soluble solids of leaf (34.4) and soluble leaf proteins (4.24). Analysis of variance for interaction between different growth stages and spraying with iron nanoparticles (A×B) recognized that just

Table 5. Mean comparison of studied traits effected by different growth stages

		Traits					
S. No	Treatments	TSS	No. of leaves	No. of internode	Ear length (cm)	Ear tail diameter (mm)	Ear wood diameter (mm)
1	A1	29.92 [a]	15.4 [a]	15.5 [a]	22.01 [a]	6.24 [a]	16.65 [a]
2	A2	32.11 [a]	15.53 [a]	15.6 [a]	24.94 [a]	7.28 [a]	18.63 [a]
3	A3	29.92 [a]	12.12 [a]	16.1 [a]	24.38 [a]	7.41 [a]	19.61 [a]

Table 6. Mean comparison of studied traits effected by spraying different concentrations of iron nanoparticles

		Traits							
S. No	Treatments	Chll a	Chll b	Cart	POX	TSS	SLPs	Ear dry weight (gr)	Seed dry weight (gr)
1	B1	2.54 ab	0.36 b	0.45 b	3.81 b	29.69 b	4.15 a	1050 a	580 b
2	B2	2.73 ab	0.37 b	0.54 b	3.83 b	34.4 a	4.24 a	880 b	470 c
3	B3	2.41 b	0.34 b	0.54 b	3.85 b	34.29 a	3.49 a	1120 a	660 ab
4	B4	2.85 a	0.51 a	0.88 a	4.82 a	30.58 ab	3.73 a	1100 a	710 a

three of the studied traits include malondialdehyde ($P \leq 0.01$), leaf width (0.05%) and ear diameter (0.05%) and have shown significant differences. Mean of comparison revealed that interaction between early flowering (A2) and applying 0.01% and 0.03% of iron nanoparticles (B2 and B3) resulted to the maximum rate of malondialdehyde with 0.027. Also effect of spraying 0/05% of iron nanoparticles in early flowering caused maximum rate of ear diameter (38.24 mm) and using iron nanoparticles 0.01% after flowering showed maximum amount of leaf width (10.8) (Tables 5 and 6).

Mosanna and Behrozyar, 2015 investigated the effect of zinc nano-chelate foliar and soil application on morpho- physiological characteristics of maize (*Zea mays* L.) in three levels of different growth stages (leaves stage, taselling and grain filling stage). Results showed significant effect of nano-chalate Zn application on characteristics include plant height, 100-grain weight, seed yield and harvest index. Also, effect of different growth stage on plant height, number of seed per row and 100-grain yield was significant ($p<0.01$). The foliar application of nano-chalate Zn had 94% more seed yield per plant. Gholami *et al.* (2013) reported that the most increase in yield was obtained as a result of iron nano chelate consumption. Also they identified that iron Nano-chelate treatment and the treatment of simultaneous consumption of Nano-chelate and superabsorbent had remarkable impact on 1000-grain weight. Morteza *et al.* (2013) studied the effect of nano TiO_2 spraying on photosynthetic parts changed maize growth at various growth stages. They detailed that the impact of nano TiO_2 was noteworthy on chlorophyll content (a+b), chlorophyll a/b, carotenoids and anthocyanins. Likewise, they reported that the greatest measure of

Table 7. Mean comparison of MDA, leaf width and ear diameter effected by interaction between different growth stages × different concentrations of iron nanoparticle

			Traits		
S. No	Treatments		MDA	Leaf width	Ear diameter (mm)
1	**A1**	B1	0.022 cd	10.31 abc	29.25 c
		B2	0.024 bcd	10.10 abc	31.10 bc
		B3	0.023bcd	10.05 bc	33.80 ab
		B4	0.025 ab	10.45 abc	38.05 a
2	**A2**	B1	0.022 d	10.30 abc	36.6 a
		B2	0.027 a	10.30bc	34.85 ab
		B3	0.027 a	10.32 abc	37.2 a
		B4	0.023 bcd	10.65 abc	38.24 a
3	**A3**	B1	0.025 ab	10.52 abc	36.6 a
		B2	0.025 abc	10.8 a	37.25 a
		B3	0.025 abc	10.62 ab	36.75 a
		B4	0.024 bcd	9.87 c	34.8 ab

color was recorded from the treatment of nano TiO_2 spray at the reproductive stage (appearance of male and female flowers) in correlation with control.

Other studies reported that the application of nanoparticles can increase crop yield such as maize yield, because of the increase of pigment amount especially at reproductive stages of plants. It includes appearance of male and female flowers for (Yang *et al*., 2006 and Morteza *et al.,* 2013). Also, Singah *et al.* (2015) indicated amplifier effect of nanoparticles. They expressed that nanoparticles facilitate site targeted delivery of various nutrients which needed for better growth and high productivity of plants. It is evident from the compiled information that effect of nanoparticles varies from plant to plant and depends on their mode of application, size, and concentrations.

CONCLUSION

Results of this study emphasized the increasing effects of nanoparticles on crops. It is indicated that many physiological and biochemical traits of Maize were intensified by the using of iron nanoparticles specially when this nanoparticles spraying during early flowering and after flowering. The significance of the role of iron in plant physiology on one hand, and challenges in calcareous soils in connection to sufficiently giving iron requirement to the plant at other hand, indicate greater need of utilizing iron fertilizer particularly as foliar application technique. It can be inferred that the iron fertilizer can enhance crop development, yield and furthermore nutritional value by expanding iron and protein (Isvand *et al.,* 2014).

REFERENCES

Alidoust D and Isoda A. (2013). Effect of gamma Fe_2O_3 nanoparticles on photosynthetic characteristic of soybean [*Glycine max* (L.) Merr.] foliar spray versus soil amendment. *Acta Physiologiae Plantarum*, 35(12): 3365–3375.

Almeelbi T and Bezbaruah A. (2014). Nanoparticle-sorbed phosphate: iron and phosphate bioavailability studies with *Spinacia oleracea* and *Selenastrum capricornutum*. *ACS Sustainable Chemistry and Engineering*, 2(7): 1625–1632.

Isvand H, Esmaeili A and Mohammadi M. (2014). Effects of iron oxide nanoparticles on some quantity, quality and physiological characteristics in wheat (*Triticum aestivum* L.) at khoramabad climate. *Iranian Journal of Field Crop Science*, 45(2): 287-298.

Gholami A, Taghizadeh M and Moalemi N. (2013). The scrutiny of interaction between iron nano chelate and chlophony hydrogel on soil chemical and nutritional properties. *Journal of Novel Applied Sciences*, 2(8): 214-218.

Graham RD, Welch RM and Bouis HE. (2001). Addressing micronutrient malnutrition through enhancing the nutritional quality of staple foods: principles, perspectives and knowledge gaps. *Advances in Agronomy*, 70: 77–142.

Ishii T, Matsunaga T, Iwai H, Satoh S and Taoshita J. (2002). Germanium dose not substitute for boron in cross-linking of rhamnogalacturonon II in pumpkin cell walls. *Plant Physiology,* 130(4): 1967-1973.

Monreal CM, DeRosa M, Mallubhotla PS, Bindraban and Dimkpa C. (2015). The application of nanotechnology for micronutrients in soil-plant systems, VFRC Report, Washington, DC USA. 44 p.

Morteza E, Moaveni P, Farahani AH and Kiyani M. (2013). Study of photosynthetic pigments changes of maize (*Zea mays* L.) under nano Tio_2 spraying at various growth stages. *Springer Plus*, 2(1): 247

Reza Mosanna and Ebrahim Khalilvand Behrozyar. (2015). Morpho - physiological response of maize (*Zea mays* L.) to zinc nano-chelate foliar and soil application at different growth stages. *Journal on New Biological Reports,* 4(1): 46 – 50.

Prasad TNVKV, Sudhakar P, Sreenivasulu Y, Latha P, Munaswamy V, Raja Reddy K, Sreeprasad Sajanlal TS and Pradeep T. (2012). Effect of nanoscale zinc oxide particles on the germination, growth and yield of peanut. *Journal of Plant Nutrition*, 35(6): 905-927.

Ajey Singh, Singh NB, Hussaina I, Singh H and Singh SC. (2015). Plant-nanoparticle interaction: an approach to improve agricultural practices and plant productivity. *International Journal of Pharmaceutical Science Invention*, 4(8): 25-40.

Tripathi KK, Warrier R, Govila OP and Ahuja V. (2011). Biology of *Zea mays* (Maize), department of bioteclmology ministry of science and technology and Ministry of Environment and Forests, Government of India.

Yang F, Hong F, You W, Liu C, Gao F, Wu C and Yang P. (2006). Influence of nano-anatase Tio_2 on the nitrogen metabolism of growing spinach, *Biological Trace Element Research*, 110(2): 179-190.